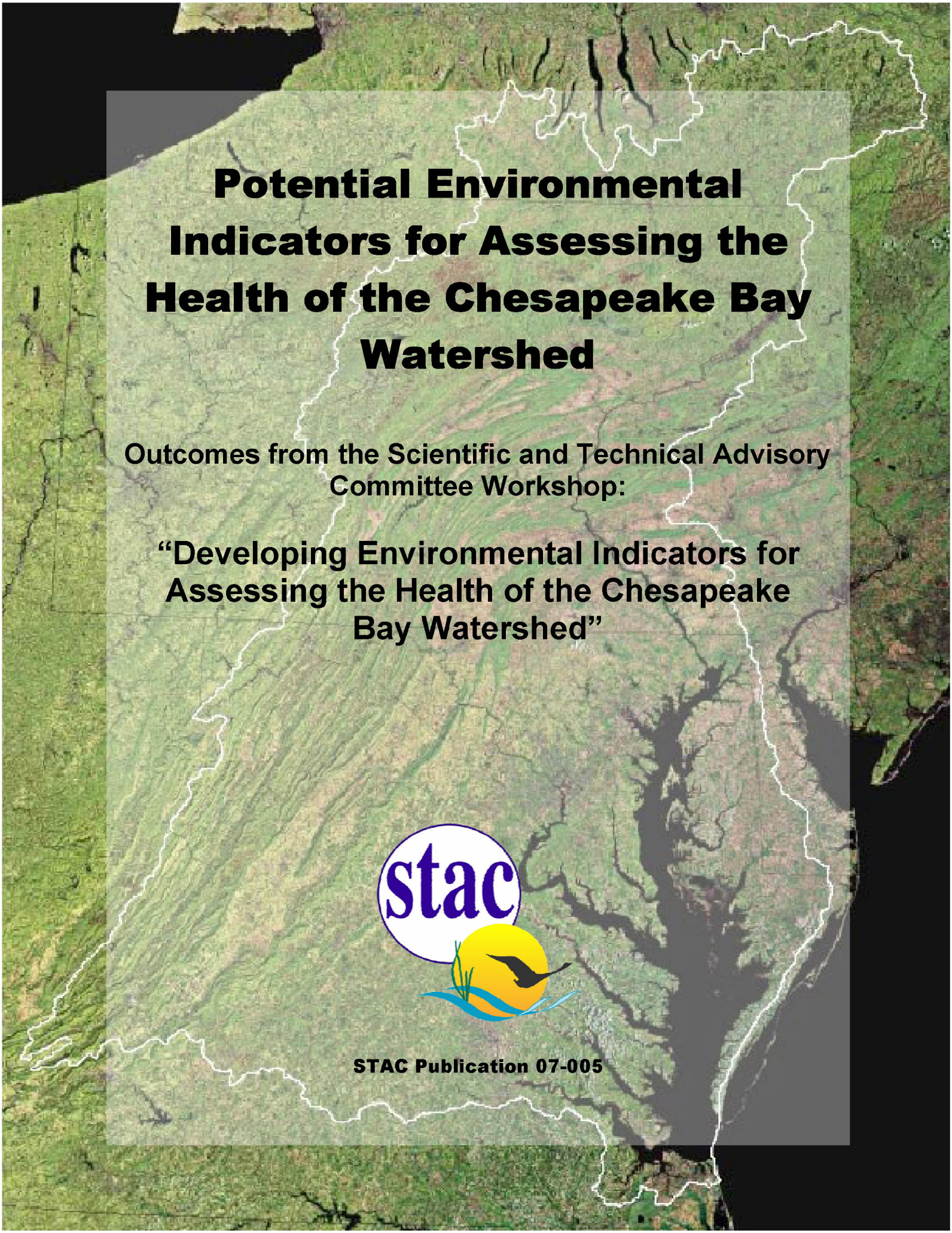

Potential Environmental Indicators for Assessing the Health of the Chesapeake Bay Watershed

Outcomes from the Scientific and Technical Advisory Committee Workshop:

"Developing Environmental Indicators for Assessing the Health of the Chesapeake Bay Watershed"

STAC Publication 07-005

About the Scientific and Technical Advisory Committee

The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports periodically to the Implementation Committee and annually to the Executive Council. Since it's creation in December 1984, STAC has worked to enhance scientific communication and outreach throughout the Chesapeake Bay watershed and beyond. STAC provides scientific and technical advice in various ways, including (1) technical reports and papers, (2) discussion groups, (3) assistance in organizing merit reviews of CBP programs and projects, (4) technical conferences and workshops, and (5) service by STAC members on CBP subcommittees and workgroups. In addition, STAC has the mechanisms in place that will allow STAC to hold meetings, workshops, and reviews in rapid response to CBP subcommittee and workgroup requests for scientific and technical input. This will allow STAC to provide the CBP subcommittees and workgroups with information and support needed as specific issues arise while working towards meeting the goals outlined in the *Chesapeake 2000* agreement. STAC also acts proactively to bring the most recent scientific information to the Bay Program and its partners. For additional information about STAC, please visit the STAC website at www.chesapeake.org/stac.

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"Developing Environmental Indicators for Assessing the Health of the Chesapeake Bay Watershed"

A Joint Workshop between the:
Scientific and Technical Advisory Committee
Monitoring and Analysis Subcommittee
Living Resources Subcommittee

Conducted February 20, 2007 in Annapolis, Maryland

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Executive Summary

The Chesapeake Bay Program (CBP) is obligated to report to the public on progress in restoring the health of the watershed. It intends to add a watershed health component to its annual "Health and Restoration assessment of the Chesapeake Bay" beginning with an assessment to be published in March 2008

The CBP Scientific and Technical Advisory Committee (STAC) sponsored a workshop on "Developing Environmental Indicators for Assessing the Health of the Chesapeake Bay Watershed" to support the development of the CBP watershed health assessment. There were two goals for the workshop, which was held on February 20, 2007:

- Identify watershed data sets, indicators, and multi-media indexes that are available for the 2008 report
- Identify promising lines of monitoring, data analysis, and research that will improve our ability to report on watershed health in future years.

Some of the major recommendations include:

- Have indicators for local watershed health conditions and others that connect the impact of the watershed on the estuary.
- Have new proposed categories for watershed health. The original categories were: water quality, habitats, and living resources. The rational is to combine water quality and in-stream corridor health into one indicator group of stream-corridors and have a watershed category to address the "landscape characteristics" of the watershed. The new proposed categories would be: (1) Watersheds, (2) Stream corridors, (3) Living Resources.
- Provide flexibility for which indicators are presented each year in the "watershed health report," given the data to develop some indicators may only be available every two years.
- Utilize State 303d information on impaired water bodies as appropriate, but it would be desirable for the CBP and states to consider a more compatible approach to assess information among the states in the watershed.
- Compare areas of similar land-cover conditions.
- Address multiple spatial scales in order to be of greater use to state and local resource managers and support CBP partner efforts for integrated geographic targeting and assessment of management actions.
- Better address the relation between environmental condition in the watershed and human health (such as having indicators based on fish consumption advisories and swimable stream conditions).
- Present the amount of uncertainty associated with an indicator, where possible.
- Develop a suite of diagnostic indicators that helps explain watershed conditions and change.
- Have the STAC Indicators Workgroup interact with Monitoring and Analysis Subcommittee (MASC) to further develop the watershed indicators.

Purpose and Goals of Workshop

The Chesapeake Bay Program (CBP) is obligated to report to the public on progress in restoring the health of the watershed. It intends to add a watershed health component to its annual "Health and Restoration assessment of the Chesapeake Bay" beginning with an assessment to be published in March 2008

The CBP Scientific and Technical Advisory Committee (STAC) sponsored a workshop on "Developing Environmental Indicators for Assessing the Health of the Chesapeake Bay Watershed" to support development of the CBP watershed health assessment. There were two goals for the workshop:

- Identify watershed data sets, indicators, and multi-media indexes that are available for the 2008 report
- Identify promising lines of monitoring, data analysis, and research that will improve our ability to report on watershed health in future years.

Overarching Issues and Recommendations

1. Develop indicators that address both local conditions and conditions that impact the estuary.

There are two overarching questions that need to be considered when addressing health of the watershed:

- What is the condition of the watershed?
- What conditions in the watershed impact the Bay?

While the CBP partners want to mostly address the second question, STAC recommends that indicators be developed to address both questions. Addressing both questions will allow the public to better understand the connection between the condition of their local watershed and stream and its impact on the Bay. Having indicators for both questions will also better inform, and therefore engage, local governments that CBP restoration activities will benefit both local governments, communities, and the estuary.

2. Have new categories for watershed health.

The CBP proposed three topics for watershed health indicators: water quality, habitat, and living resources. STAC recommends that these categories be modified to:

- Watershed landscape health
- Stream corridor health (would include water quality and in-stream measures of condition)
- Living resources

Water quality and in-stream corridor health would be combined into one indicator group of stream-corridor health. There would be another category of watershed "landscape" health. Some examples of indicators that would be in each category are shown in Table 1.

Table 1: Some Potential Watershed Health Indicators:

Watersheds

- Acres of forest cover (tie to goals in the CBP Forest Directive)
- Acres of nontidal wetlands cover (tie to CBP goal to restore wetlands)
- Landscape development index
- Channel ditching/altered connectiveness

Stream Corridors

a. Water-quality:

- Nitrogen, phosphorous, sediment loads (Compare to tributary strategy load "caps")
- Selected contaminants (based on State 303d lists)
- Dissolved oxygen (based on State 303d lists)
- pH (based on State 303d lists)
- Pathogens (based on State 303d lists)

b. Habitats:

- Physical and hydrologic conditions of streams and riparian zones and floodplains, such as connectiveness of riparian forest buffers, stream stability based on hydrologic conditions.

Living resources (in-stream and watershed)

a. Potential indicators for living resources in streams:

- Benthic IBI
- Fish IBI
- Periphyton

b. Potential indicators for living resources in the watershed:

- Conditions of bird populations (based on breeding bird surveys)
- Conditions of Amphibians
- Conditions of Mammals

STAC also recommends developing a framework of watershed indicators that may build toward an overall index of watershed health. However, the usefulness of the index by stakeholders should be evaluated before it is undertaken. We also recommend that a suite of diagnostic indicators be developed to help explain watershed condition and change.

3. Provide flexibility for which indicators are presented each year given the data to develop some indicators may only be available every two years.

Many of the proposed indicators may not show significant annual change or may not have data available for annual updates. Therefore, STAC recommends that the watershed report not be constrained to having the same indicators presented each year. The report may want to emphasize different topic areas each year, such as forecasting and vulnerability, to identify areas to focus ecosystem conservation efforts.

4. Utilize State 305b report information on impaired water bodies, but provide a more compatible approach to assess information among the states in the watershed.
The State approaches for assessing and listing of "impaired streams" for the 303d lists and 305b reports differs across the watershed. For example, Maryland lists an entire watershed while other states list stream reaches. Therefore trying to use the current CBP state partner approaches may not provide adequate indicators for watershed conditions. STAC recommends that the CBP may have to develop other approaches or have the states develop more comparable approaches for indicators of watershed health.

5. Compare areas of similar land-cover conditions.
STAC recommends that the CBP develop indicators and assessments that compare "like" areas (such as comparing urban areas to each other and not an urban area to a forested area). This will provide more valuable information about watershed health than trying to compare all land-cover conditions to a "pristine" reference watershed.

6. Address multiple spatial scales to be of greater use to state and local resource managers.
STAC recommends that indicators be developed to address several spatial scales that include:

- Entire Bay
- Tributary strategy basins
- 14 digit Hydrologic Unit Codes (HUC)

Ultimately providing information at the 14 digit HUC scale is most desirable because management decisions are made at this scale and differences between watersheds are most evident at this scale. This local scale includes county governments that have the authority to make planning decision and implementing restoration activities. There are some counties that already have assessments to make more informed environmental decisions. The goal would be for the watershed health report to provide information to other counties so they can make more informed decisions.

7. Support CBP partner efforts for integrated geographic targeting and assessment of management actions.
The STAC recommends that one of the goals be watershed health indicators to inform geographic targeting and assessment of management actions. This will allow more effective implementation of management actions using available resources.

8. Better address indicators of human health.
The STAC recommends that the CBP have a stronger emphasis on indicators of "human health." Examples include advisories for consumption of fish or if a water body is swim able. Another approach is to report the percent of stream miles that obtain the designated use.

9. Present the amount of uncertainty associated with an indicator
Understanding uncertainty of measures (indicators) is important. STAC recommends that where techniques exist for estimating uncertainty, it should be reported. Where techniques don't yet exist, developing those techniques will require new investments.

Potential Indicators

The workshop had breakout groups for three major topics (1) water quality, (2) habitat, and (3) living resources. Three topics were addressed in each breakout session: (1) possibilities for 2008 reporting level indicators, (2) ideas for future reporting indicators, and (3) information gaps and ideas for new indications. The outcomes for each session are presented.

Potential Water-Quality Indicators

The session focused on evaluating water quality parameters that may be useful for developing watershed health indicators. There was an emphasis on assessing water quality information that is already being used by the states to determine condition of streams for aquatic life and human health as part of the 305b assessment reports and 303d listing process. The following parameters were discussed and evaluated: nitrogen, phosphorus, sediment, contaminants, pathogens, dissolved oxygen, pH, conductivity, and temperature. There was discussion about which indicators would be most promising to answer the questions:

- What is the condition of the watershed?
- What conditions in the watershed impact the Bay?

Water-quality indicators developed to address condition of the watershed could be constructed from the water-quality parameters collected and analyzed by the states for their 305b assessment reports and 303d lists to identify impaired waters. These parameters include nitrogen, phosphorus, sediment, contaminants, pathogens, dissolved oxygen, and pH. However, technical issues were identified about the comparability of information between states that may prevent using the information to assess the health of the entire Bay watershed. For example, the process to list a stream as impaired differs between states. Maryland uses the information collected from streams to list an entire watershed as impaired, while the other states usually list a segment of a stream as impaired. Additionally, the states collect and report the information at different spatial resolution. This can give the impression that there are more miles of impaired streams in one state than another.

Nitrogen
Nitrogen may not be a good indicator to address the question: What is the condition of the watershed? This is because nitrogen is mostly used to assess suitability of stream water for drinking water supplies. Nitrogen may be more useful as an indicator to address the issue about watershed conditions impacting the Bay. To address this issue the CBP continue to improve the indicator for total nitrogen load to the Bay by having a

goal that is based on the states' tributary strategy basin cap load allocations. The CBP should also develop an indicator showing areas of high nitrogen reaching the Bay. Some other considerations for developing nitrogen indicators include:

- Could make statements at the 10 major tributary strategy basins based on loads at the river input stations.
- Currently do not have a monitoring station at the lower end of all the 40+ tributary strategy basins, but have sampling station designs in place within the non-tidal water quality monitoring network.
- Need to consider normalizing nitrogen loads given the wide fluctuations in river flow conditions.
- Proceed with a nitrogen load-based indicators for tributary strategy basins based on the non-tidal water quality monitoring network and predicated on the adopted cap load allocations by the states' tributary strategy basins.
- Spatial scale is directed towards larger scale watersheds; the CBP should try and advocate use of the smaller scale data sets.
- Need to develop better diagnostic indicators of sources of nitrogen loads in the watershed.

Phosphorus

Phosphorus does not provide a good indicator for watershed health because it has limited connections to defining the health of local watersheds/streams/rivers and is not a concern to human health. Like nitrogen, phosphorus would be useful indicator to address watershed conditions that impact the Bay. The CBP should improve the indicator for total phosphorus load to the Bay by having a goal that is based on the states' tributary strategy basin cap load allocations. The CBP should also develop an indicator showing areas of high phosphorus reaching the Bay.

Sediment

Sediment may be a good watershed indicator because it is both a local watershed/water body concern and a Bay tidal water issue. There is potential to develop several indicators. One could be focused on habitat integrity for non-tidal streams and rivers. Another indicator should be an improvement of sediment load to the Bay indicator by including a goal that is based on the states' tributary strategy basin cap load allocations. The CBP should also develop an indicator showing areas of high sediment reaching the Bay. There are several existing efforts that could be evaluated to develop sediment indicators for watershed health:

- The Maryland Biological Stream Survey provides data that could be used to make connections between sediment levels/concentrations and impacts on aquatic life and their habitats. Field crews make a number of qualitative measures of the stream habitat (e.g., embeddedness).
- Virginia's freshwater probabilistic monitoring network provides comparable data to the Maryland Biological Stream Survey, through analysis of benthic organisms, fish communities, habitat, and water quality.
- States do have 303(d) listings based on sediment due to impairments to the benthic infaunal community.

Contaminants

The group recommended that any contaminants indicator be based on the states' 303(d) listings for chemical contaminants given the lack of routine CBP monitoring for contaminants across the watershed. However, even the current state monitoring is limited in both spatial and temporal scales, with sampling generally prompted by specific needs, events, and issues. Currently, the states have 303d listings principally for PCBs, mercury, and some pesticides. The most promising indication may be based on the fish consumption advisories, but there are concerns about comparability of these advisories between the states given differences in water quality standards and the approach for determining the relative risk to human health. Additionally, the indicator would be based on spatially limited data and would not change much from year to year due to usually slow changes in concentrations within fish tissue.

Other Potential Water-Quality Indicators

The other potential indicators that were discussed included dissolved oxygen, pH, conductivity, temperature, and pathogens. Of these, pathogens may be the most important for local streams but more information is needed to determine the extent of information available for this potential indicator. The states do have water-quality standards for dissolved oxygen and pH in freshwater streams and could be potential indicators for water-quality health of streams. Temperature and conductivity were not considered as likely potential indicators.

Development of watershed water-quality indicators would relay in many cases on the States 303(d) and 305(b) information. There were both ideas and concerns about trying to use the information to develop indicators for the entire watershed. Some of the major points included:

- Build a set of indicators directly from the existing states' 303(d) listing related to specific causes of impairments.
- Assessments are done every two years with data 1-2 years older; therefore indicators showing annual changes will be difficult to develop.
- Concern that the existing 303d lists include waters that were previously listed for reasons that may not be now fully justified from the available data.
- Concerns about comparability of data and listing approaches between the states.

Potential Habitat Indicators

The discussion of watershed habitat indicators converged around four primary issues:

- The spatial definition of habitat, i.e., were there multiple habitat types within a watershed?
- The addition of human habitat descriptors.
- The relevant spatial scale(s) at which to describe habitat.
- The appropriate reference standards.

Each is discussed below.

Habitat, as it pertains to previous CBP indicators, was spatially defined as the physical conditions within the water body of interest, relevant to the living resources of interest (e.g., acres of submerged aquatic vegetation for fish and shellfish). The spatial definition of habitat becomes much broader for watershed indicators, and includes conditions within the entire watershed, the riparian corridor, and the stream itself. Thus, the three habitat types will each require a unique set of indicators (we recommend the inclusion of water quality parameters under in-stream habitat; see Overarching Issue #2). Strict delineations between these elements are not always ecologically appropriate, and the conditions of each habitat type are certainly correlated. For example, the land cover of a watershed is related to the water quality of its stream. The discussion highlighted the need for an improved understanding of watershed processes that provide linkages between watershed, riparian corridor, and in-stream habitat characteristics. In addition, many organisms will require high quality habitat in all three habitat types. For example, an organism such as the Louisiana Waterthrush needs large blocks of forest for breeding territory (watershed conditions), nesting sites within a forested riparian corridor, and a high quality stream to support the necessary macroinvertebrate population.

While the spatial definition of habitat type is important, so, too, is the relevant living resource for which the habitat is being described. Previous Bay indicators were naturally focused on the primary living resources in the Bay itself. Watershed indicators must also address the primary living resources in its domain, including humans. Humans are part of – not apart from – ecological systems. This is especially apparent for watersheds.

Spatial scale is an important consideration for the selection of indicators. While the first generation of watershed indicators was designed to provide useful broad-based snapshots of regional-scale water quality and habitat condition, they have not been effective at scales (i.e. watersheds, ecosystems) relevant for many management decisions (Niemi et al., 2004). The spatial scale of indicators can be matched to the most common scales of effective management actions. The spatial scale of a small watershed, or 14-digit Hydrologic Unit Code (HUC) is often a scale of decision-making that appears to be effective. Successful restoration efforts are often performed at this scale, since a single watershed organization or political entity can manage the activity. The restoration and management activities of the CBP appear to take place at three primary spatial scales: the small watershed, a tributary basin, and the entire CB watershed. Watershed habitat indicators should, then, be developed at all three spatial scales.

To interpret any set of indicators, one must compare the results to a relevant standard or benchmark (i.e., reference standard). Traditionally, environmental benchmarks have been taken from systems devoid of human impact. As most landscapes are managed with the intention of supporting continued human use, this is neither practical nor realistic. This is especially true for watershed indicators, since upland areas and riparian corridors are areas of intense human activity. In addition, stream order and ecoregion are primary determinants of some ecosystem characteristics. Thus, three axes of ecological characteristics are relevant for the description of reference standards: watershed land cover (as a descriptor of human use), stream order, and ecoregion.

With these issues in mind, the habitat discussion group proposes the following indicators for consideration and development for 2008 reporting:

Watershed Habitat

% forested cover in watershed (can be reported at multiple spatial scales)

In-stream Habitat

% stream miles degraded;
% stream miles buffered

Riparian Corridor

Wetland quantity, type, and condition;
Stream/floodplain connectivity (entrenchment ratio, hyperconnectivity index)

Human Habitat

Degree of wellhead protection;
Air quality;
% of wastewater discharge receiving tertiary treatment;
Per capita cost of water treatment and supply

In addition, general ideas for future reporting indicators are as follows:
Upstream quantity and quality of connected fish passage;
Relative bed stability;
Index incorporating inverse distance-weighting of land cover and roads.

Potential Nontidal Living Resources Indicators

Potential Living Resource Indicators Identified by Breakout Group (not listed in priority order):

- Benthic macroinvertebrate index of biotic integrity (IBI)
- Fish Health
- Human population health
- Periphyton
- Fish Index of Biotic Integrity (IBI)
- Biological Diversity
- Rare, Threatened, and Endangered Aquatic Species
- Herepetofauna (Reptiles and Amphibians)
- Resident bird populations
- Fish Passage

Options to Pursue for Near-Term Action:

- *Benthic macroinvertebrate IBI* – biomonitoring, unlike chemical monitoring which provides information about water quality at the time of measurement, will provide information about past and/or episodic pollution. Benthic macroinvertebrates are

ideal for use in biomonitoring because; they are ubiquitous; occur in the smallest headwater streams; relatively sedentary; pollution tolerance varies among species; are relatively easy to collect and identify; and are being widely used to assess the condition of non-tidal waters.

- Maryland, Virginia, West Virginia, and now Pennsylvania each have a multi metric macroinvertebrate index. Potential issues of consistencies between States would need to be addressed through an interagency workgroup. Many interstate comparability issues have already been addressed for the Potomac watershed (Austin 2006, 2007). An opportunity may exist to work through VERSAR to identify and link methods to reference condition standards.

- Opportunity to use the "Wadeable Streams Assessment" sampling methods, a probability based survey initiated nationwide in 2004, provided a consistent approach for collecting and interpreting macroinvertebrate data for a repeatable bay-wide indicator of non-tidal streams status and trends. The "Wadeable Streams Assessment" will be repeated in 2009.

- Opportunities exist to create benchmarks relative to a management objective which the partners can use to compare stream health in the future, thereby enabling the Chesapeake Bay Program to evaluate the effectiveness of stream protection and restoration efforts. For example, using a benthic macroinvertebrate IBI to reflect the structure and function of a stream community as compared to reference streams within a similar region. Using IBI ratings of good, fair, and poor, the Chesapeake Bay Program could set overarching stream restoration targets that say, for example, "less than 25% (or X percent) of the region's streams are classified as poor," or "more than 75% (or X percent) of the region's streams are classified as good."

- Combining benthic macroinvertebrate community integrity with a measure of fish health or a fish IBI will provide a more integrated picture of stream health.

- *Fish Health* – Fish communities are good indicators of overall stream habitat quality because they are exposed to many physical and chemical stressors throughout their life cycles and they show a range of tolerances to stream condition.

  - Opportunity exists to track the visible presence of lesions and tumors on fish collected as part of current non-tidal monitoring programs. Interagency workgroup would need to agree to a set of consistent reporting standards.

  - The combination of fish health and benthic macroinvertebrate community integrity will provide a more integrated picture of stream health.

Options to Pursue for Future Indicators:

- *Human Population Health* – Measures of the human population as a living resource indicator within the ecosystem (rather then just as a stressor). Indices collected could include population numbers, population growth rates, projected population numbers, infant mortality, life expectancy, asthma incidences, and average family income. As human populations in the watershed continue to grow, the indicator could track how communities accommodate growth in ways that ensure the health and sustainability of human settlement

- *Periphyton* There is an opportunity to develop a periphyton indicator for assessing watersheds. Periphyton biomass and species composition can assess and possibly predict both local water quality conditions and watershed nutrient loads, in that biomass increases in a predictable manner with nutrient concentrations. As periphyton biomass is closely correlated with total phosphorus and total nitrogen concentrations among streams and lakes, Pennsylvania and Virginia are considering using biomass and taxonomic composition of periphyton to potentially set Total Maximum Daily Loads (TMDL) thresholds. The Maryland Department of Natural Resources is considering adding a periphyton component to their biological stream survey pending the further development of defined and interpretable periphyton indicators.

- *Fish Index of Biotic Integrity* – More complete indices of fish health that include several measures that describe community structure, community function, pollution sensitivity, proportion of introduced species, etc. have been developed by many states and could be another useful indicator of stream/river condition. Interagency effort would be required to develop compatibility.

- *Biological Diversity* – The presence or absence of certain species in stream or river communities can help pinpoint specific stressors or groups of stressors on a system. Using certain benthic taxa to compare systems with high and lower diversity was discussed. Indices of biological diversity could be applied across other organisms both aquatic and terrestrial within the system.

- *Herpetofauna (Reptiles and amphibians)* – Excellent indicators of stream and watershed health as their survival depends on the physical make-up of both the water and terrestrial components of the watershed. Maryland has developed a multi-metric salamander indicator that may be added to their biological stream survey after 2009. Salamander indicators may be useful assessment tools, especially in headwater streams with few or no fish species.

- *Resident Bird Populations* Development of a bird integrity index that uses bird assemblage information to assess stressors to a system. To assess riparian integrity, it was recommended to use resident over migratory bird survey data. For public communication reasons, a bird index could be a useful management

tool. It was recommended to use the bird index in conjunction with watershed data and aquatic indicators to get a more complete picture of watershed health.

- *Non-native Species Indicators* – Use a percentage of stream miles or watershed having different numbers of non-native species. An opportunity exists to further distinguish invasive from non-invasive and species of priority concern.

- *Fish Passage* – Total fish passage counts of all species. Automated technology is available that can track all fish passing the field of the fish-way camera. Total fish counts may prove more useful then focusing only on alosids.

Overarching Comments:

- The Bay watershed states are monitoring and assessing the condition of their non-tidal streams and rivers. However, because sampling designs and collection methods vary among the partner states, it is not yet possible to describe the status of streams/rivers for the entire Bay watershed. No benchmark of stream/river status has been developed against which the effects of various protection and restoration efforts can be compared. Until this benchmark status is documented, it will be impossible to make any data supported statements about whether non-tidal streams/rivers in the Bay watershed are getting better or worse.

- Measures of the invertebrate community integrity offer the best opportunity to develop a repeatable bay-wide living resource indicator in the near-term, which could be greatly enhanced by combining measures of fish health. However, human population health may offer the most significant opportunity for developing a meaningful "engagement" indicator for the future.

- The Chesapeake Bay Program's Monitoring Program intent as a "watch-dog" monitoring program does not meet the current demand to observe, understand, and reliably report on ecosystem processes. The understanding of key ecosystem stressor processes is limited by the observational data. For example, the Bay Program cannot determine whether hypoxia leads to positive or negative population dynamics of key ecological and economic species. Higher resolution data in time and space is needed.

- In-stream indicators (biological and physical habitat indicators) are currently being used throughout the watershed to depict the health of non-tidal streams. However, to describe "watershed health," these indicators would need to be coupled with appropriate indicators for other aquatic components (e.g. rivers, wetlands, lakes), plus biological and habitat indicators appropriate for the terrestrial components of watersheds.

Developing Diagnostic Indications and Connections between Indicators

While the intent of various CBP reporting requirements is to convey information concerning condition and restoration progress to the public, it is important to recognize that the indicators developed for these uses represent but a small portion of the management questions present in the Chesapeake Bay watershed. Environmental management efforts are generally and collectively directed at answering the following basic questions:

1. How big is the problem (e.g., where is the resource, and what is its condition)?
2. Is it getting better or worse?
3. What's causing it?
4. What can be done (e.g., how can we improve the ecological functioning of the impaired system, and what level of functioning is sustainable)?
5. Is management making a difference?
6. How do I communicate any of the above to the public?

Thus, the indicators discussed in this report are specifically aimed at answering questions #1 and #6, and can be utilized over a period of time to answer questions #2 and #5. What is missing is a suite of indicators to determine the cause of the problem and what can be done to address it (questions #3 and #4). Indicators that serve these latter purposes are generally termed "diagnostic" indicators, and identify the causative factors of condition and, in the best of cases, demonstrate an unequivocal dose-response relationship. These are often condition indicators, as well. Examples include light and density of submerged aquatic vegetation, and eggshell thickness and DDT. Identification of factors at a multitude of spatial and temporal scales may be required. For many management decisions, particularly at larger spatial scales, associations among condition and stressor indicators, rather than dose-response relationships, can be sufficient. In a recent study of existing CBP indicators, only three out of thirty ecological indicators could be classified as diagnostic (Hershner et al., 2007). We recommend the development of diagnostic watershed indicators, and propose the following for consideration:

- Measures of impervious surface within watersheds
- Measures of the amount of channelization and/or ditching
- Various measures of land cover that incorporate impact, such as the Land Development Index or urban intensity measures

Other Potential Ideas for Future Collaboration between STAC and MASC

STAC and MASC will utilize some of the overarching recommendations given in this report as the basis for an agenda of cooperative activities. The issues, and a short description of potentially relevant opportunities for collaborative work, are:

Develop indicators that address both local conditions and conditions that impact the estuary. STAC has formulated a standing committee to initially develop the process for independent indicator review, selection, and retirement. STAC will submit a draft of the procedure to MASC, and the two groups will work together to define this process. Additional roles for the STAC Indicator Subcommittee in the future may include

participation in the indicator process. STAC participation in expert review of individual indicator assessments would only occur under special circumstances, i.e., a member of STAC is a recognized local expert in the specific indicator under review.

Provide flexibility for which indicators are presented each year. STAC and MASC will work together to draft a five year reporting schedule, considering alternating reports on the condition of the watershed with reporting on various risks (e.g., climate change impacts, biofuel production on water quality, etc) to the Bay posed by watershed activities.

Compare similar areas and conditions. STAC and MASC will consider the construction of appropriate benchmark, or reference, watershed classifications. For example, a watershed classification that takes into consideration prevalent land cover classes would allow urban watersheds to be compared to other urban watersheds, instead of forested ones.

Support CBP partner efforts for integrated geographic targeting and assessment of management actions. STAC can investigate the scientific defensibility of reporting information at various spatial scales, to inform MASC's selection of reporting activities.

Better address indicators of human health. STAC can comment on the scientific defensibility of various proposed indicators, or can develop guidelines as to preferred characteristics of human health indicators.

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